The drivers and patterns of total phosphorus across lake, stream, and wetland ecosystems at the national scale

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A horizontal bar chart titled "Publications" showing the number of publications by ecosystem type:
- lake + wetland + stream: 2 publications!
- lake + wetland: ~100
- wetland + stream: ~100
- lake + stream: ~200
- wetland: ~2,100
- lake: ~6,200
- stream: ~5,300

X-axis: Publications (0 to 6,500)

Integrated Freshwater Landscape
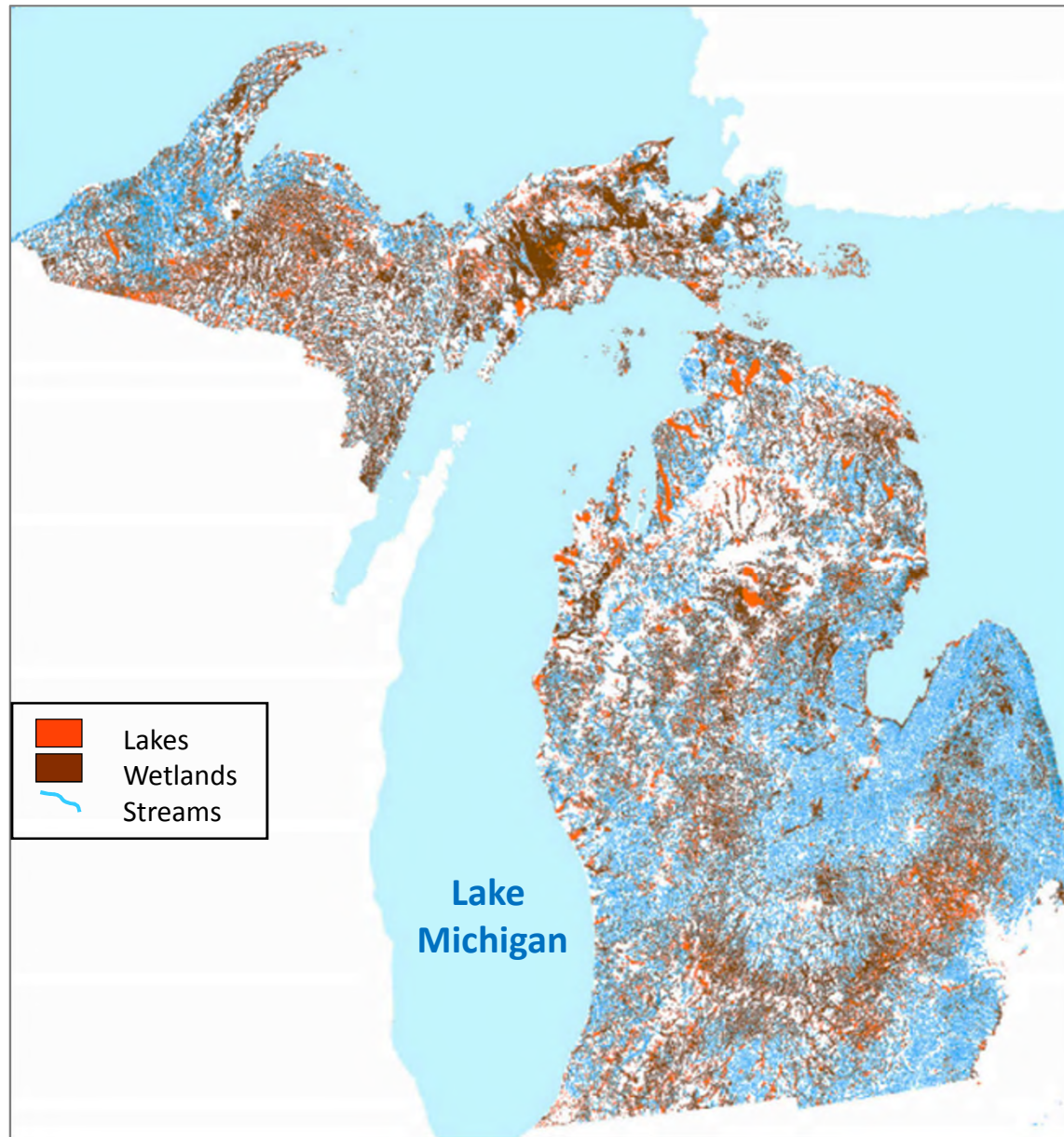
Dataset: US EPA National Aquatic Resource Survey

Lake assessment 2012
Wetland assessment 2011
River/Stream assessment 2008/2009

Lakes (n=1130)
Wetlands (n=401)
Streams (n=2124)

https://www.epa.gov/national-aquatic-resource-surveys/nrsa
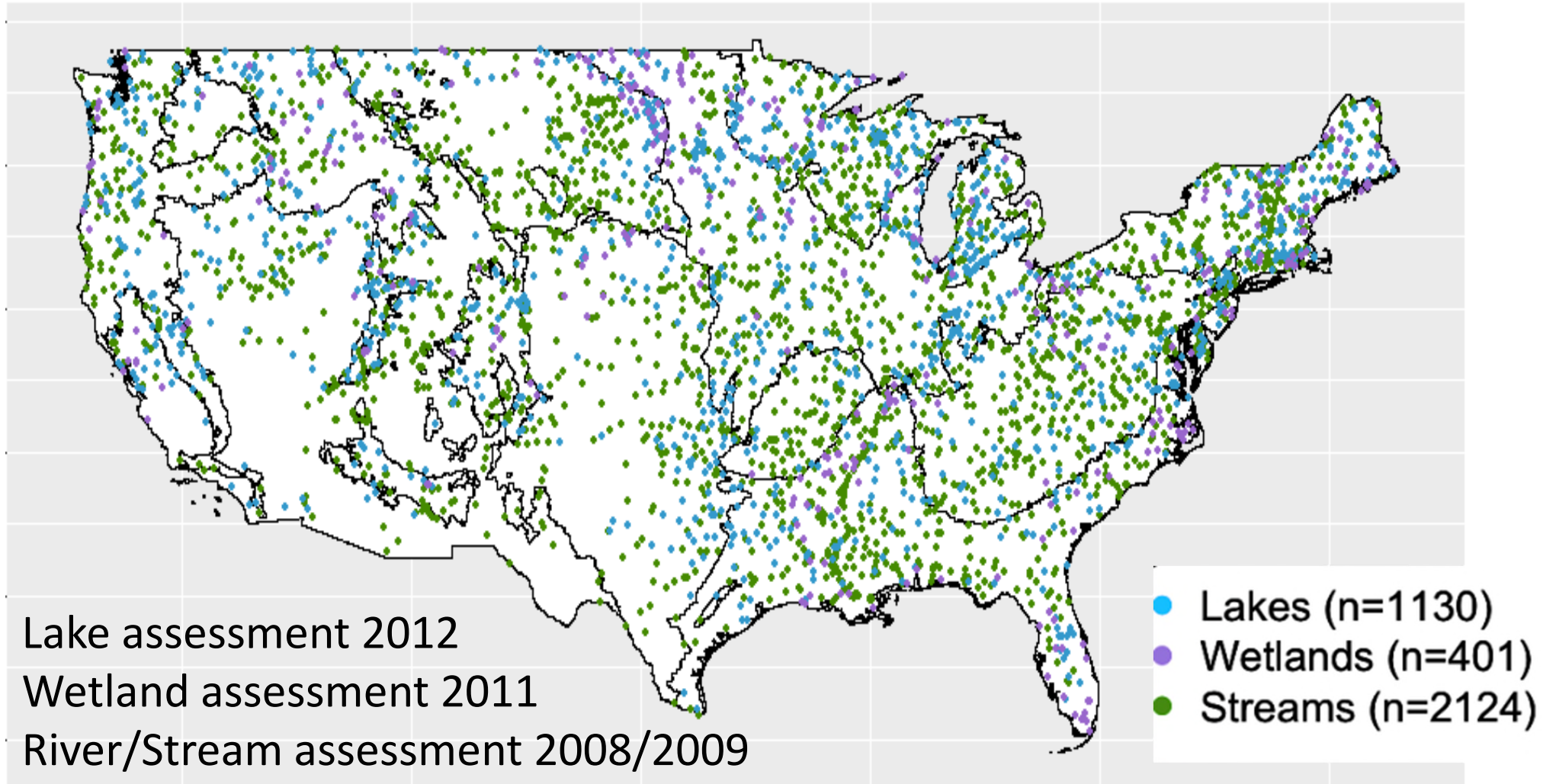
Dataset: Total Phosphorus (TP)
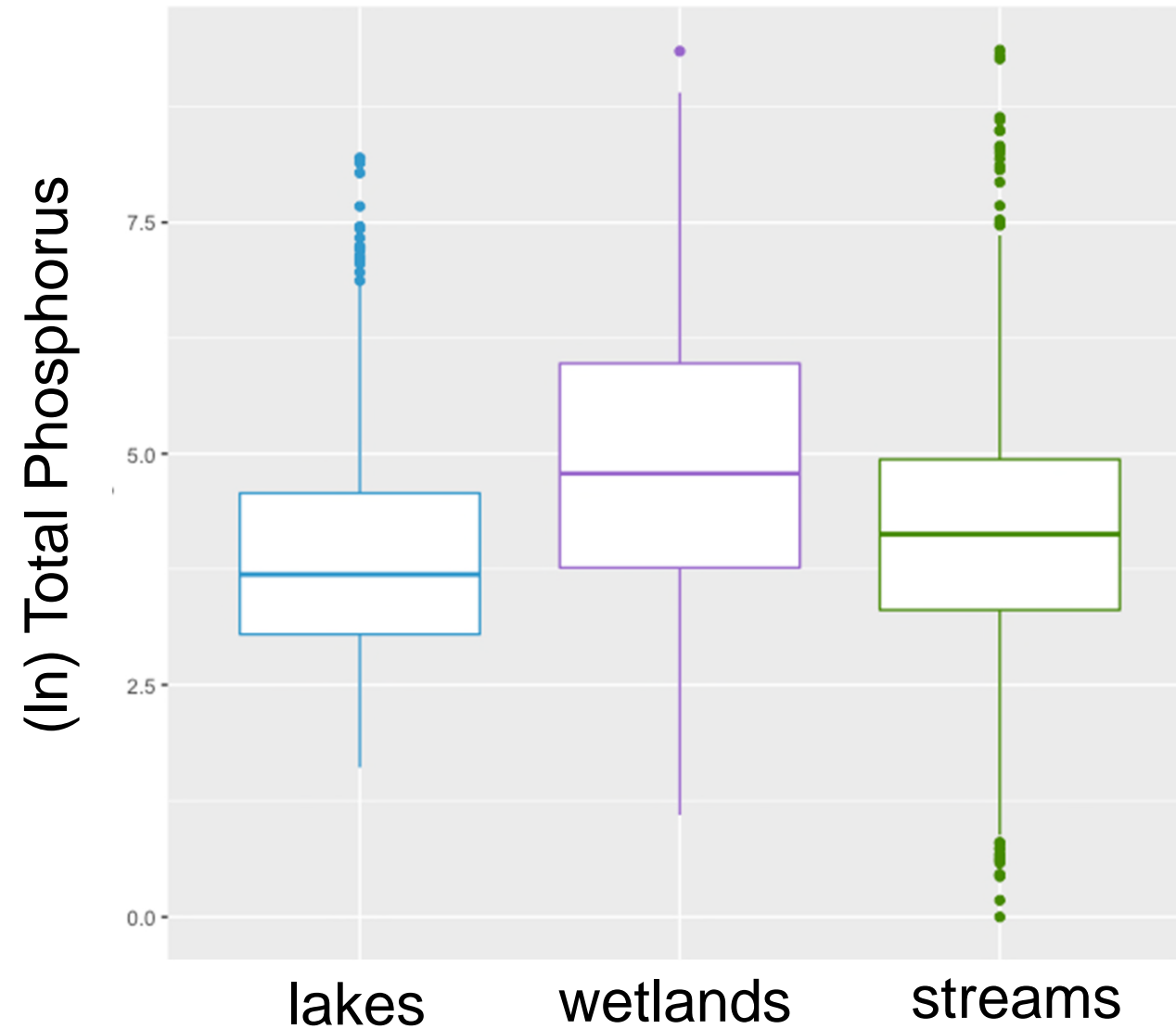
Dataset: Ecological context

Waterbody scale:
- freshwater type
  - (lake, wetland, stream)
- depth
- % riparian vegetation
- lat/lon of site
- precipitation at the site
- temperature at the site

Watershed scale:
- mean elevation
- land use/cover
- nitrogen deposition
- road density
- population density
- watershed area*

Ecoregion:

Ecoregion membership consisting of similar land use, topography, climate, and natural vegetation

*no wetland watersheds, approximated with 1000m buffer

Q1: What are the **drivers** of total phosphorus across lakes, wetlands, and streams at the macroscale?
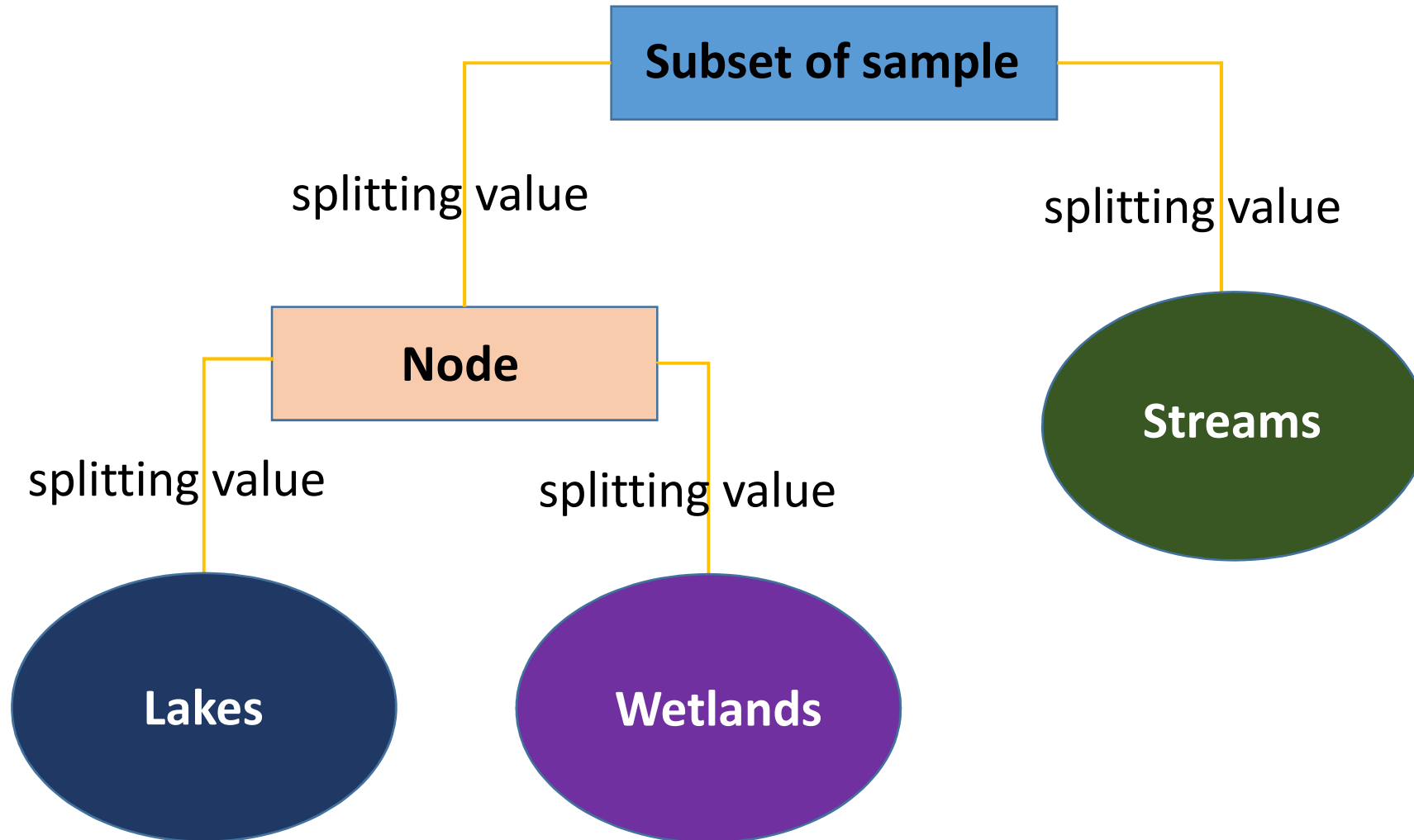

lakes

wetlands

streams

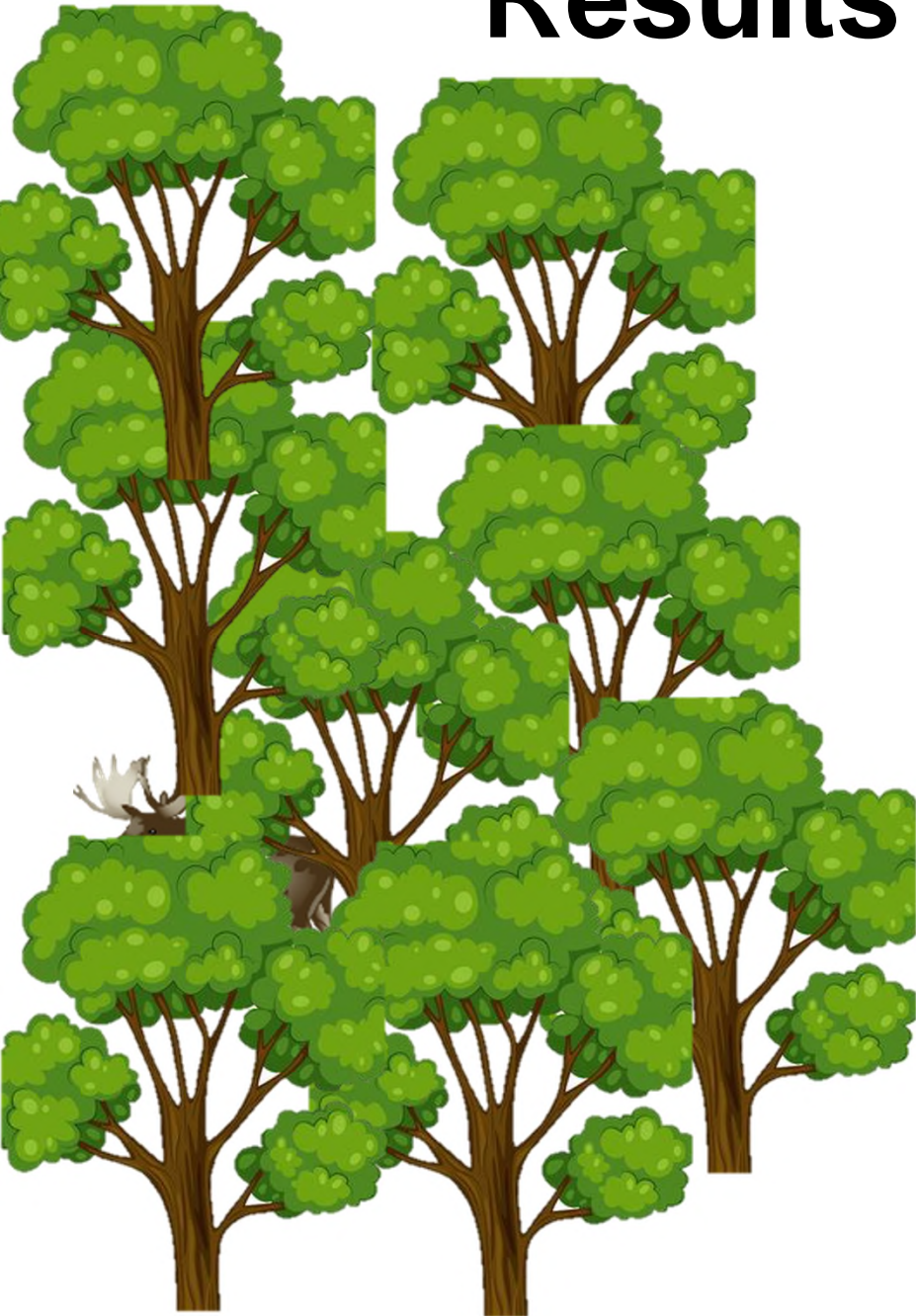# **Hypothesis:** freshwater type will be important in predicting TP

- Depth
- lentic vs. lotic
- water residence time
- form/shape

Q1 Method - **drivers** – Random Forest

Subset of sample

splitting value

splitting value

Node

splitting value

splitting value

Streams

Lakes

Wetlands

Results - important drivers of TP

- watershed % forest

- watershed % agriculture

- longitude
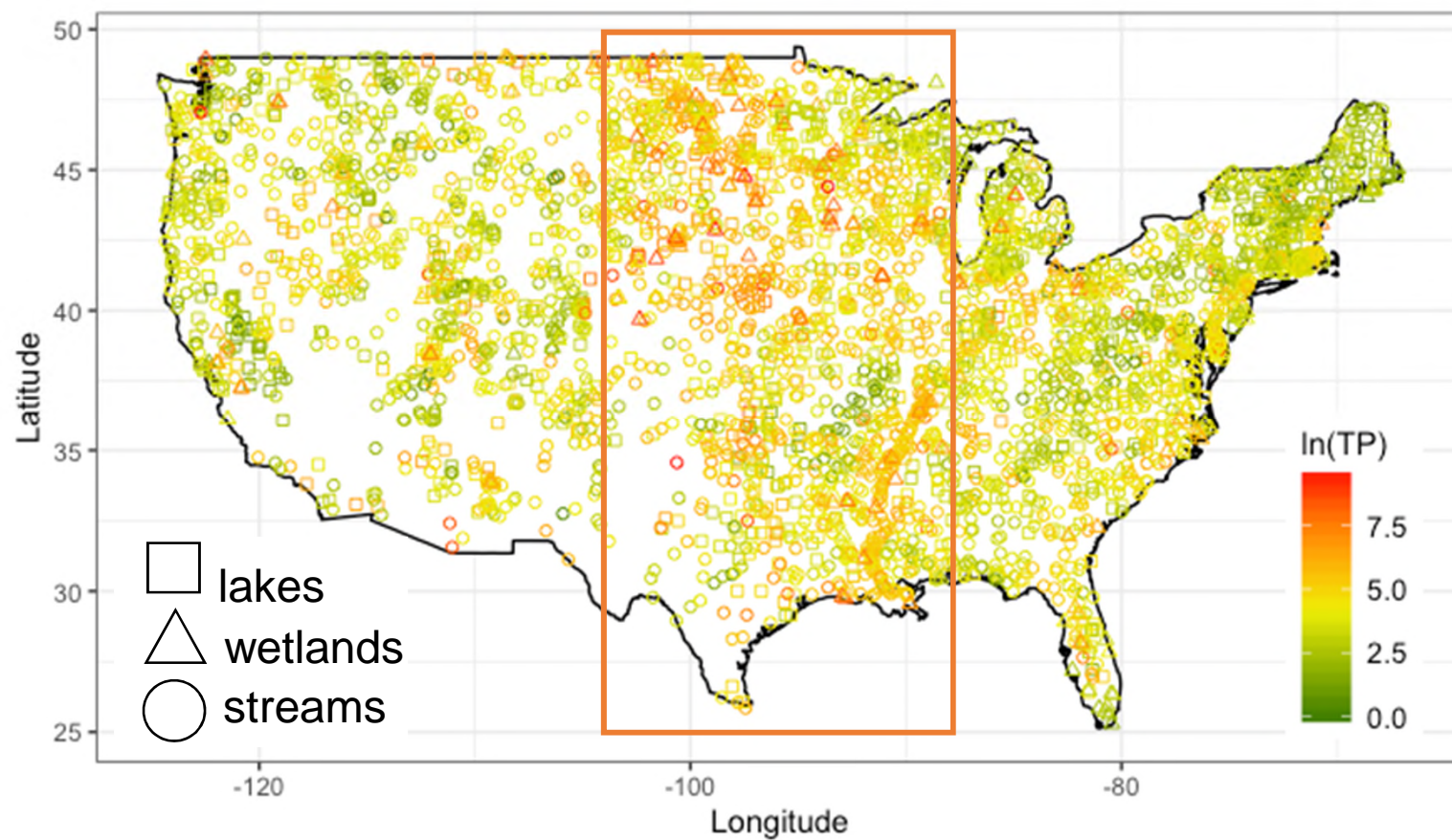
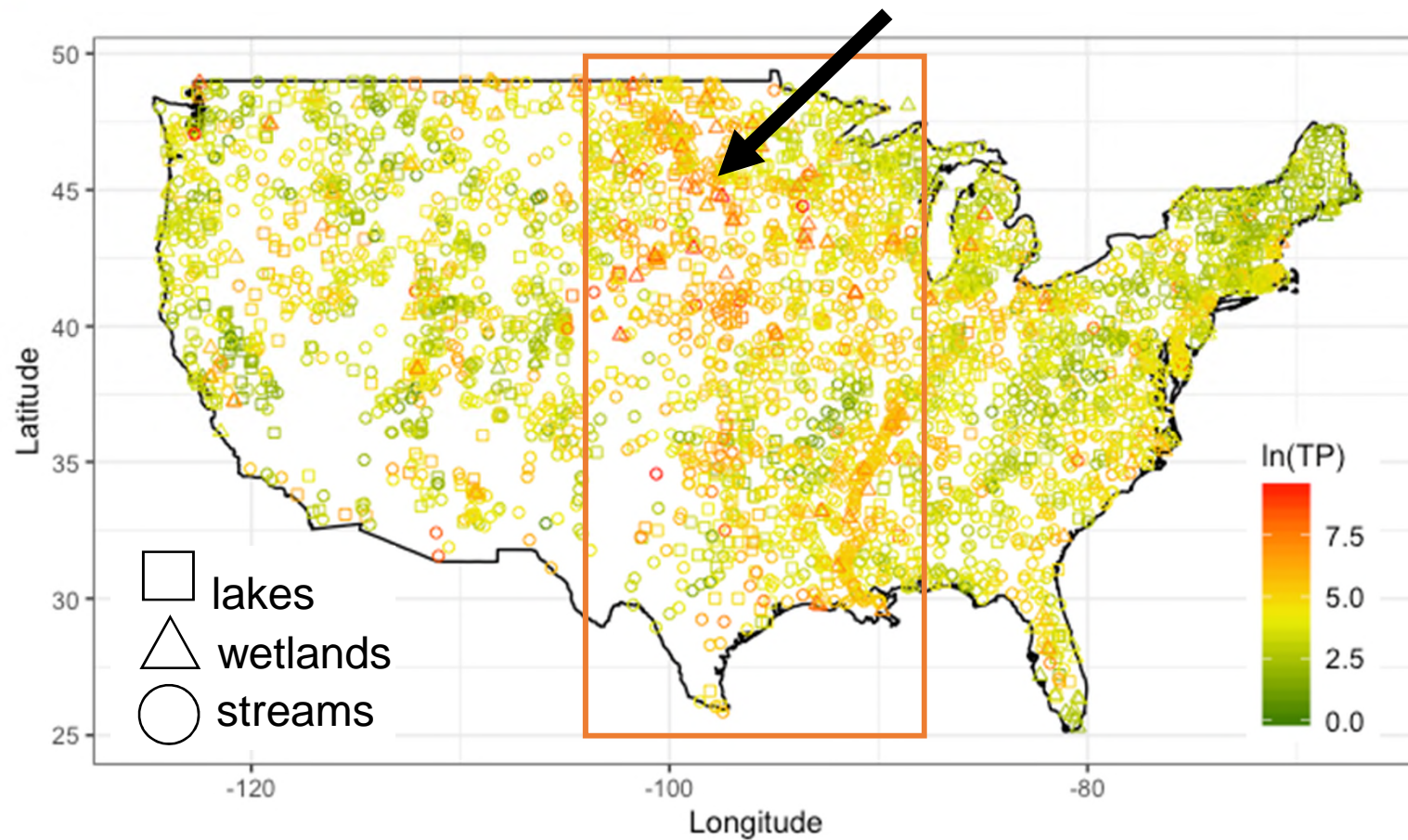- ecoregion membership

Percent variance explained = 50.0

Forest

Total Phosphorus

ln(TP)
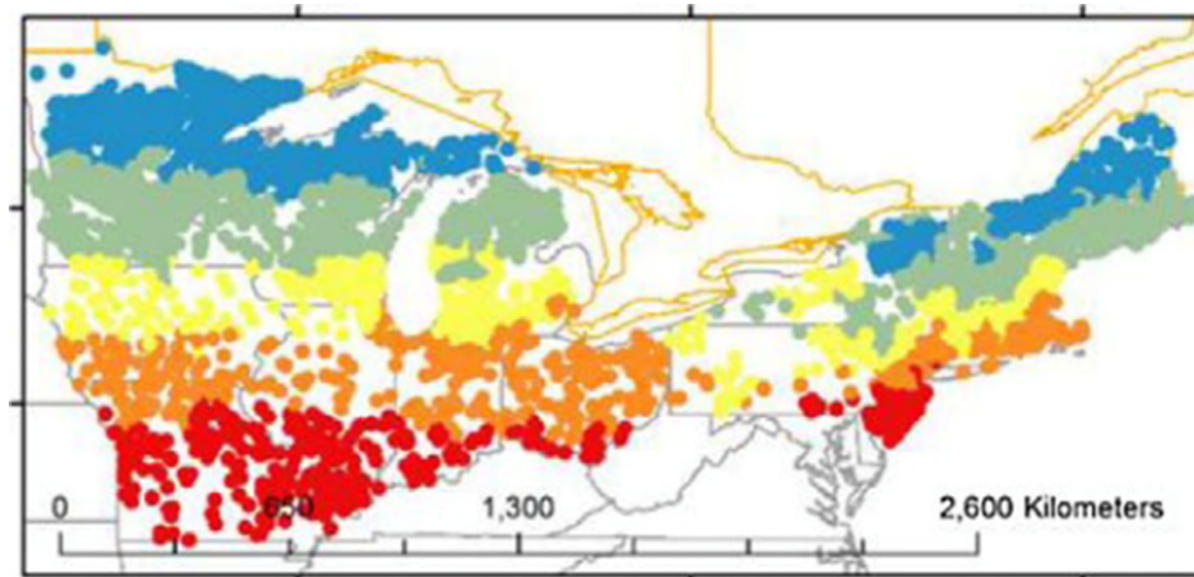
7.5

5.0

2.5

0.0

☐ lakes
△ wetlands
○ streams

Total Phosphorus

Agriculture

- □ lakes
- △ wetlands
- ○ streams

ln(TP)

7.5

5.0

2.5

0.0
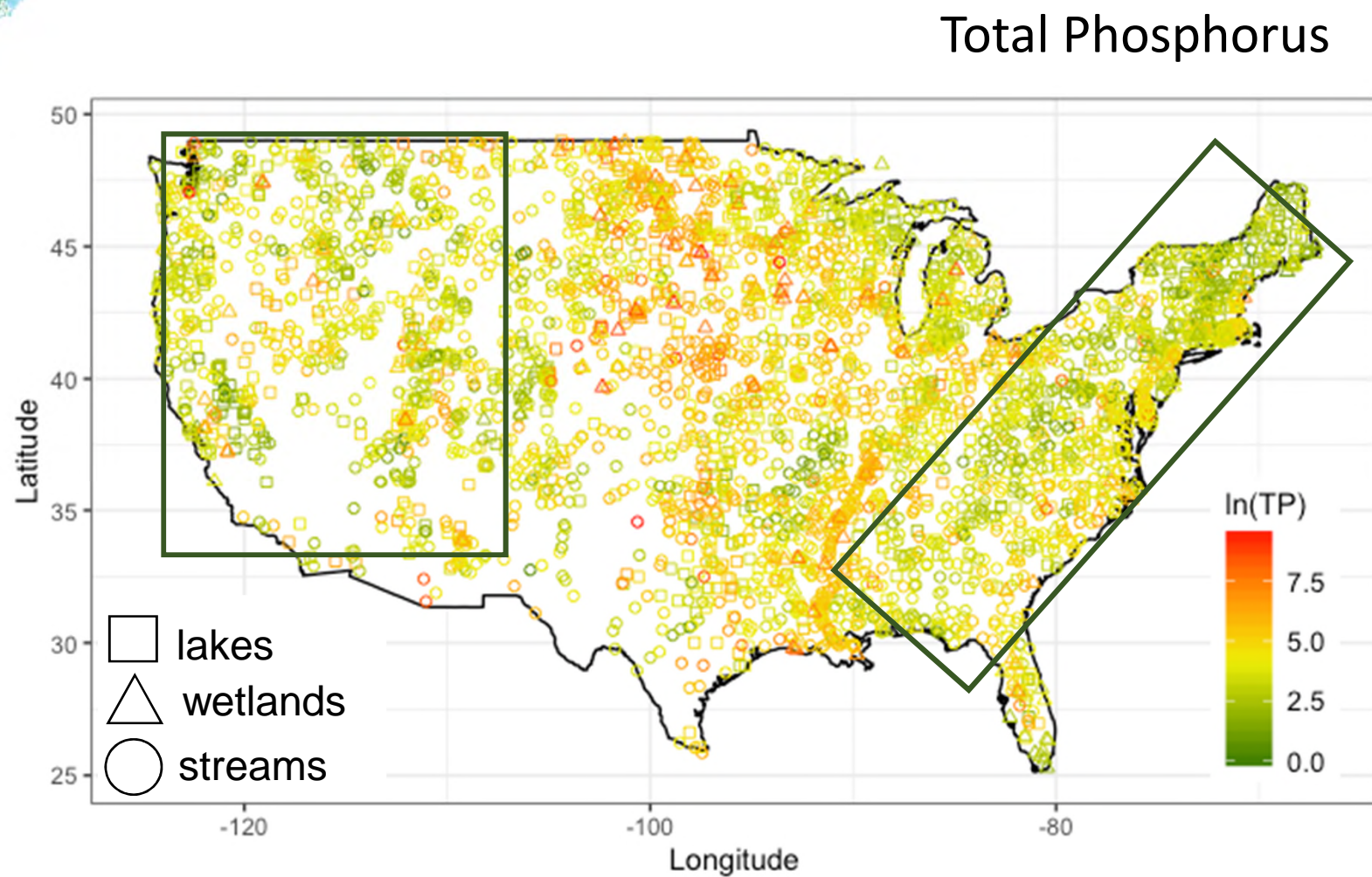
Agriculture

Total Phosphorus

□ lakes
△ wetlands
○ streams

ln(TP)

7.5

5.0

2.5

0.0

Spatial Patterns

Mean Annual Temperature

Lapierre et al. 2018

Q2: What are the spatial **patterns** of TP and its important drivers at the national scale?

Hypothesis: Total phosphorus and its important drivers will show similar patterns
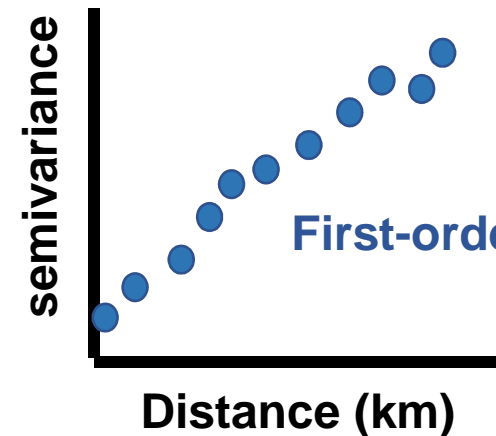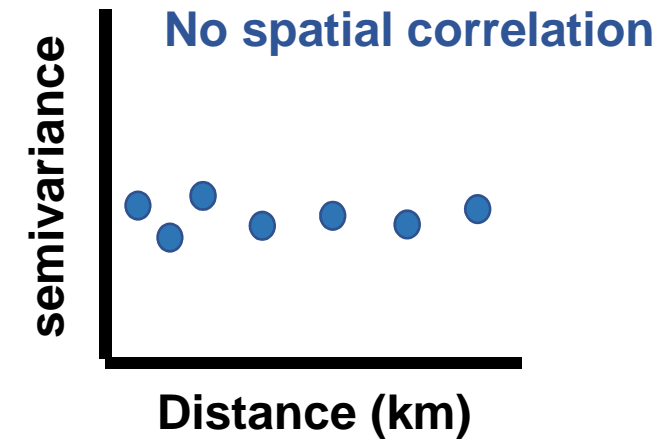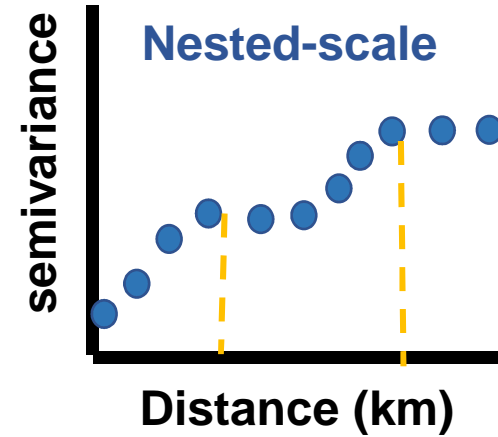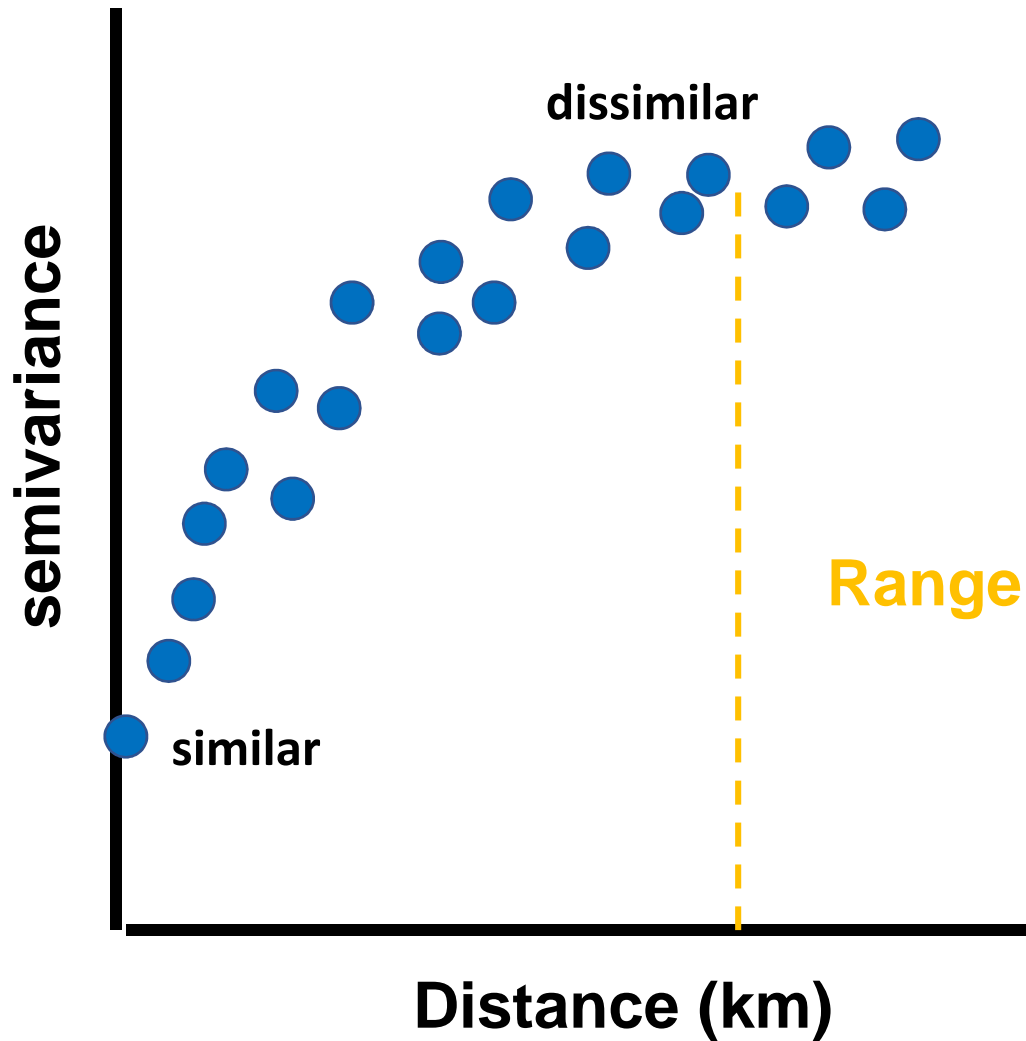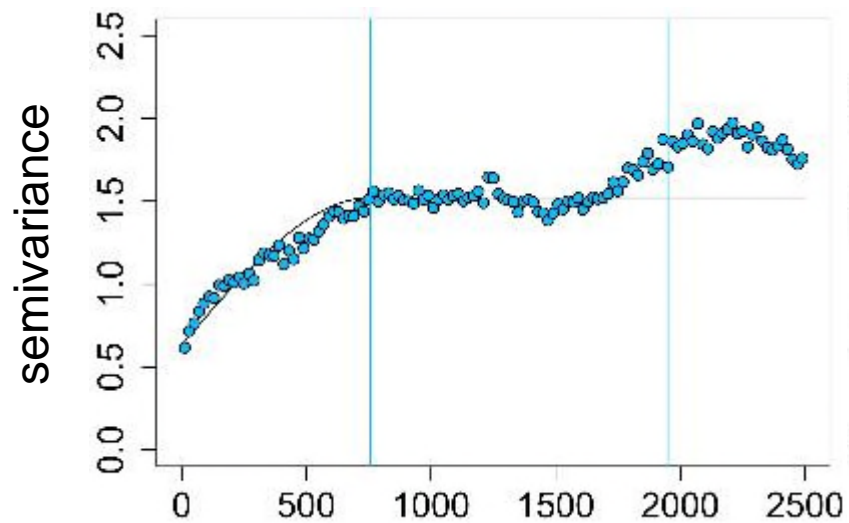

lakes

wetlands

streams

Quantifying Macroscale Patterns:
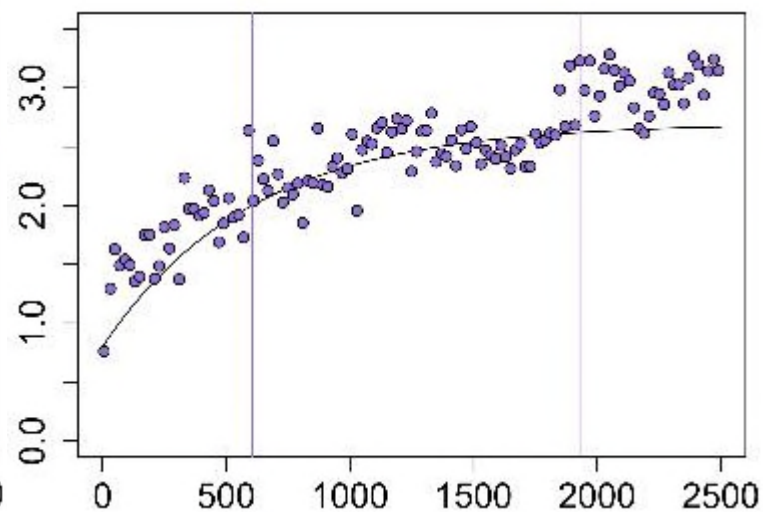# Spatial Autocorrelation
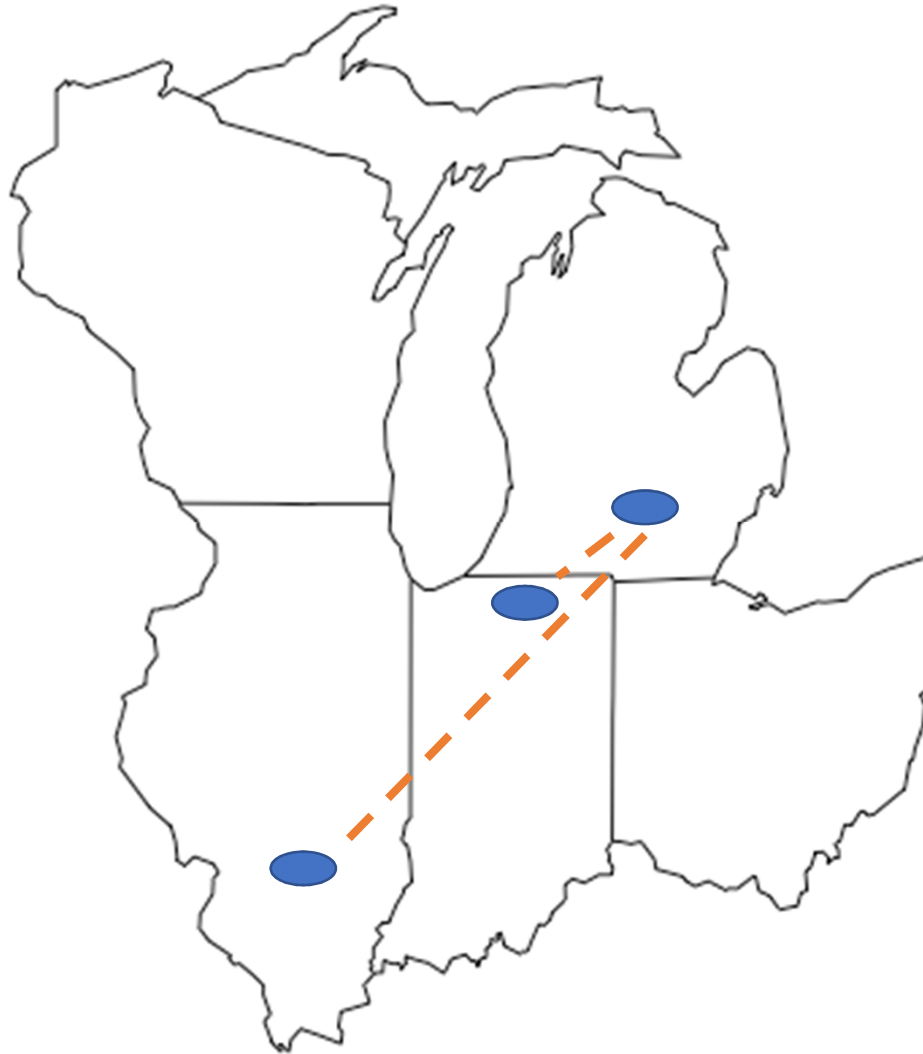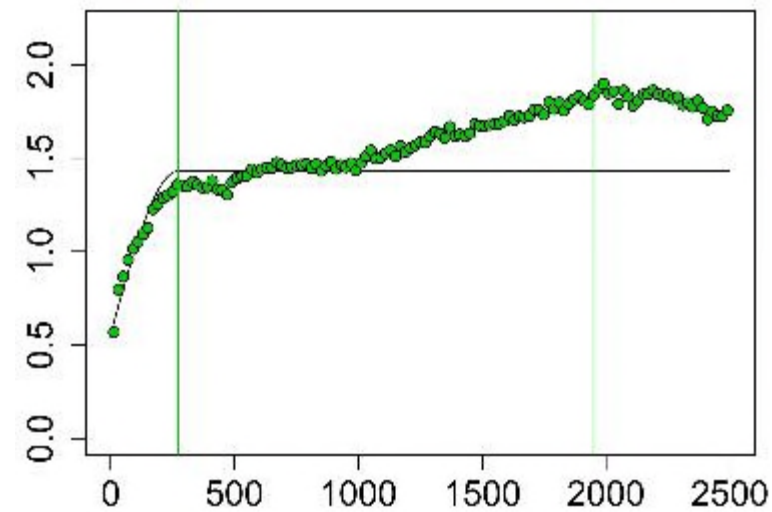
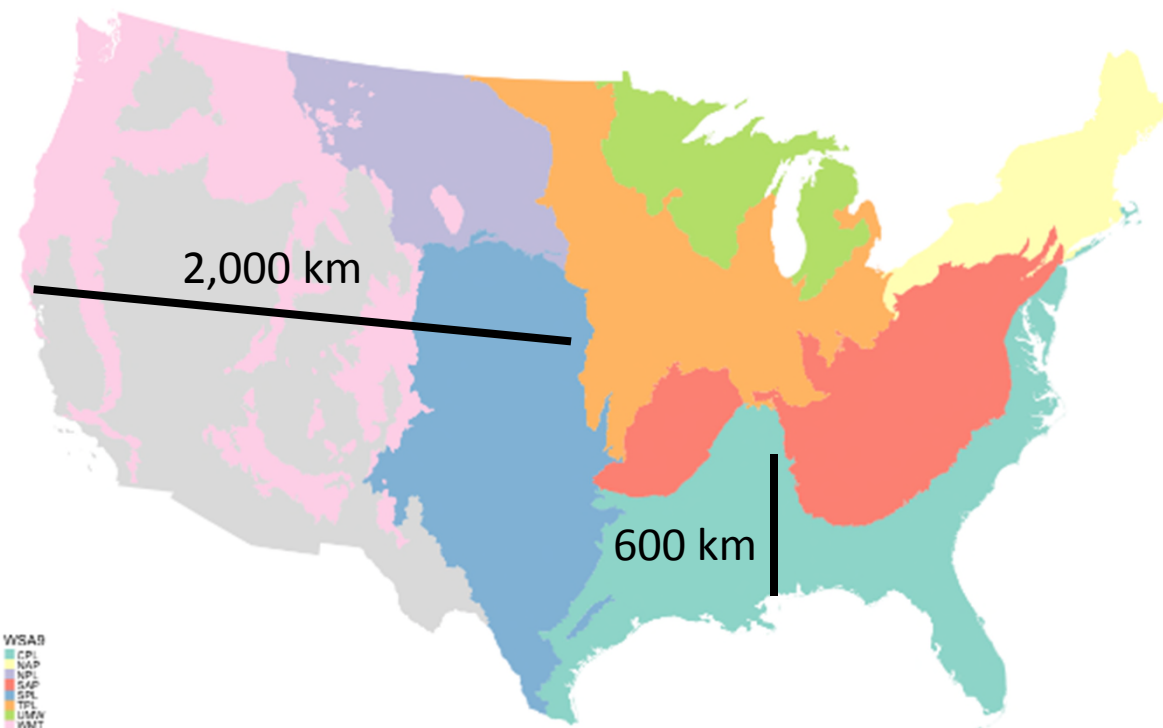# Q2: Method - Patterns – semivariograms
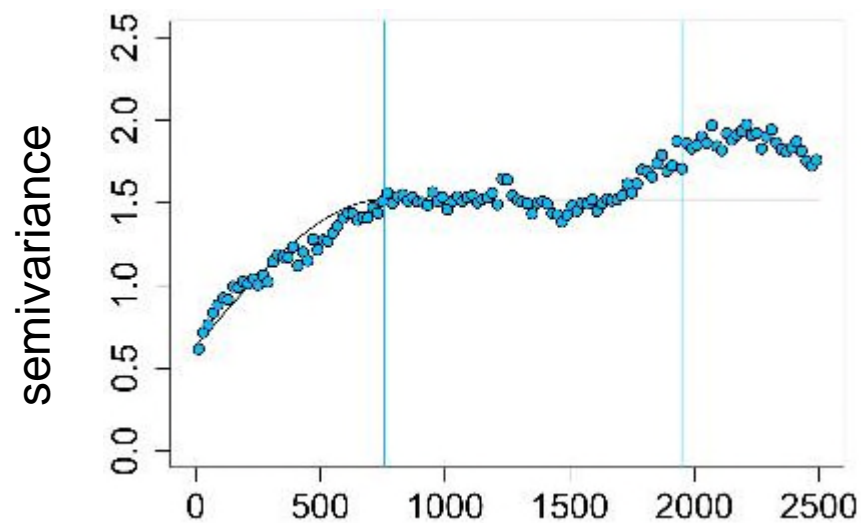
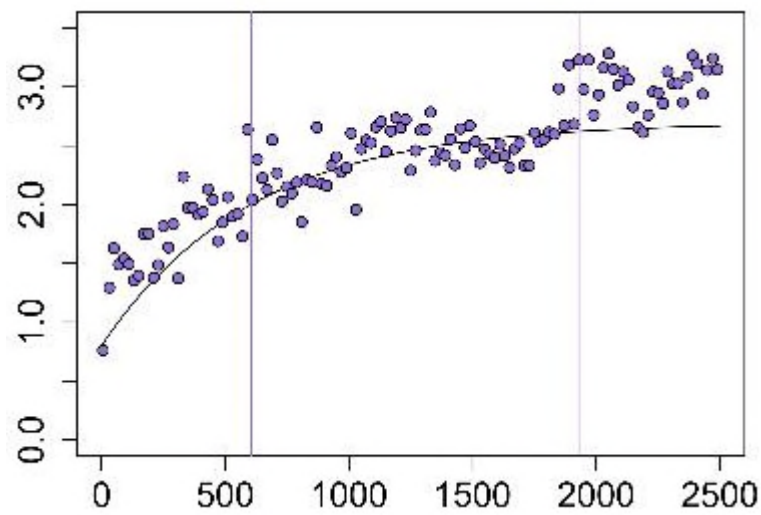## TP lakes

TP wetlands

TP streams

semivariance

Distance (km)

2,000 km

600 km

King et al. (*in review*)

TP lakes TP wetlands TP streams

% forest % agriculture

semivariance

Distance (km)

King et al. (*in review*)
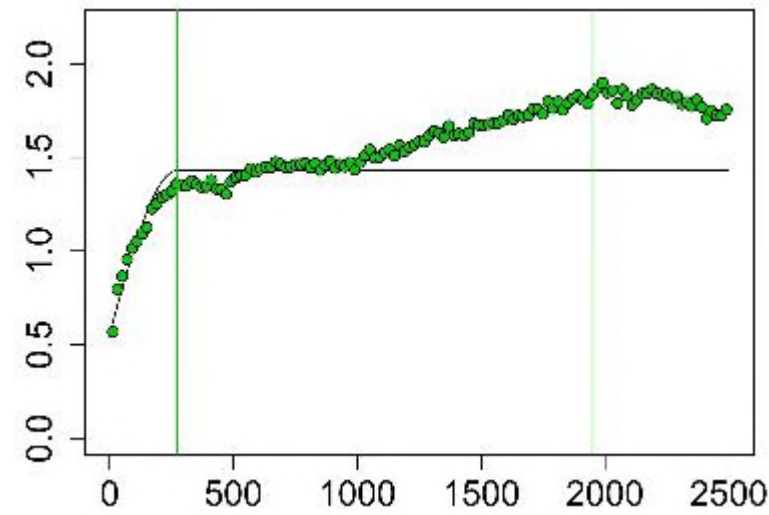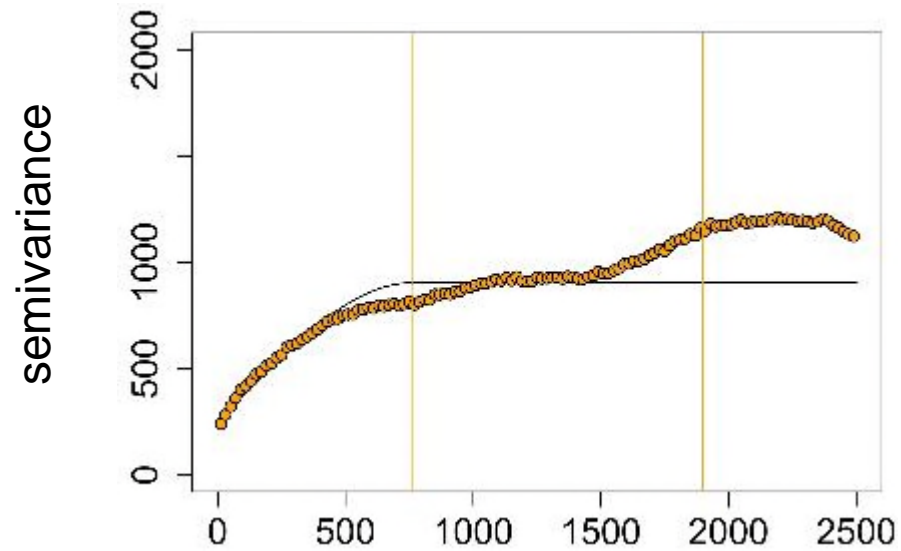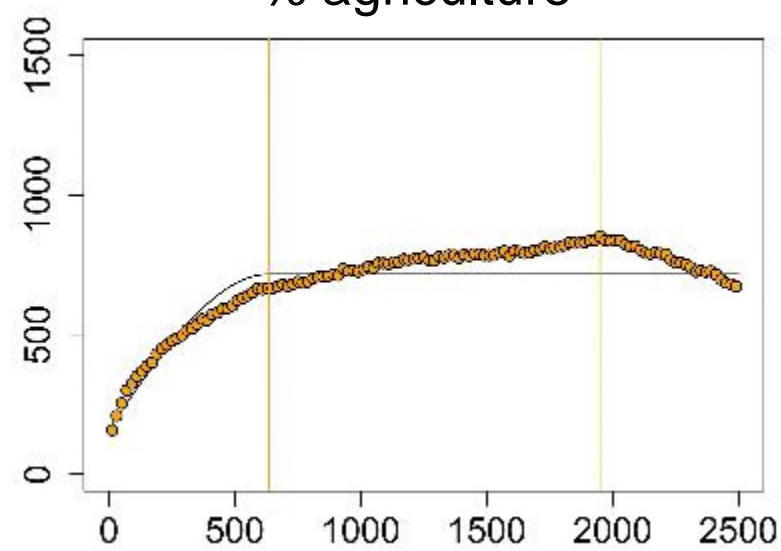
Conclusions

- Q1 – drivers of TP across lakes, wetlands, and streams at the national scale are the same
  - Percent aquatic vegetation differed across freshwater type
- Q2 – patterns of TP across lakes, wetlands, and streams at the national scale are the same

Implications

https://phys.org/news/2017-09-rebuild-hurricanes-wetlands-significantly-property.html

Image Courtesy of FISRWG

1. Land use intensification affects **all** ecosystem types
   - % forest and % agriculture are top drivers of TP
   - Any land use policy changes are widespread (wetlands, streams, lakes)

Implications

2. Integrating across ecosystem types at the macroscale
- Multiple spatial scales are important in all types
- Management can cross state boundaries

Recommendations

Wetlands:
- More freshwater wetlands
- Delineate wetland watersheds
- Sample macroinvertebrates in wetlands (for comparing biota)

- All types: Coordinate sampling sites

Acknowledgements

- EPA state and federal agencies who collected data

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- Continental Limnology

- Data-intensive Landscape Limnology Lab

Questions?

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